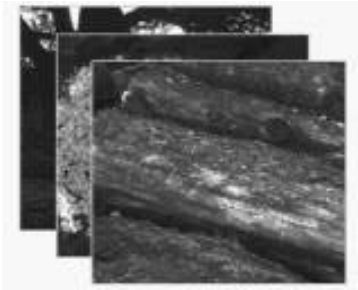

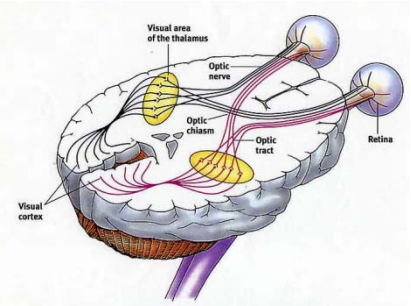

Main Subject Detection via Adaptive Feature Selection

Cuong Vu and Damon Chandler

Image Coding and Analysis Lab

Oklahoma State University

Main Subject Detection is easy for human …




Outline

- **Introduction**
- Algorithm
- Results and Analysis
- Conclusion and Future work

Outline

- Introduction
- **Algorithm**
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- Conclusion and Future work

Outline

- Introduction
- Algorithm
- **Results and Analysis**
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Outline

- Introduction
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- Results and Analysis
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Outline

- **Introduction**
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Introduction

- Photographers convey their ideas in photos via one or more main subjects.
- Human visual system pays more attention to some parts of images.
- Applications of Main Subject Detection (MSD)
  - Auto cropping a photo
  - Image compression
  - Unequal error protection
  - Object recognition
  - Etc.

Previous work

- Algorithms to detect the main subject in an image
  - **Y. Ma** *et al.*, "Contrast-based image attention analysis by using fuzzy growing," in MULTIMEDIA '03, New York, USA, pp. 374-381, ACM, 2003.
  - **J. Luo** *et al.,* "A computational approach to determination of main subject regions in photographic images," Image and Vision Computing, vol. 22, no. 3, pp. 227 – 241, 2004.
  - **T. Liu** *et al.,* "Learning to detect a salient object," IEEE Conference on Computer Vision and Pattern Recognition, pp. 1-8, 2007.
  - **R. Achanta** *et al.,* "Frequency-turned Salient Region Detection", IEEE Conference on Computer Vision and Pattern Recognition, 2009.

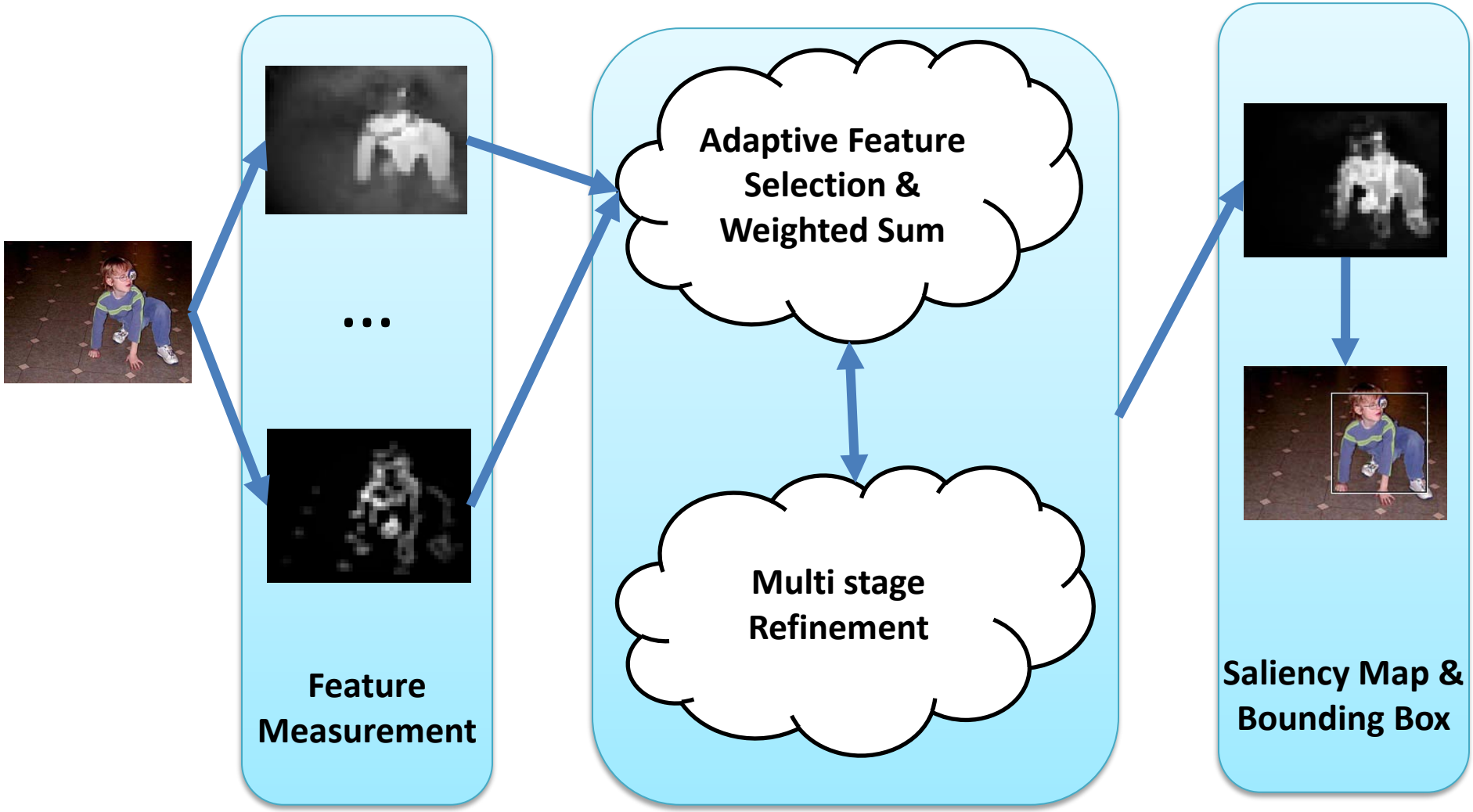
Previous work

- Algorithms predict visual fixation
  - **L. Itti** *et al.,* "A model of saliency-based visual attention for rapid scene analysis," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 20, no. 11, pp. 1254 – 1259, 1998.
  - **O. L. Meur** *et al.,* "A coherent computational approach to model bottom-up visual attention," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 28, no. 5, pp. 802 – 817, 2006.

Outline

- Introduction
- Algorithm
- Results and Analysis
- Conclusion and Future work

Algorithm


...
Feature Measurement
Adaptive Feature Selection & Weighted Sum
Multi stage Refinement
Saliency Map & Bounding Box

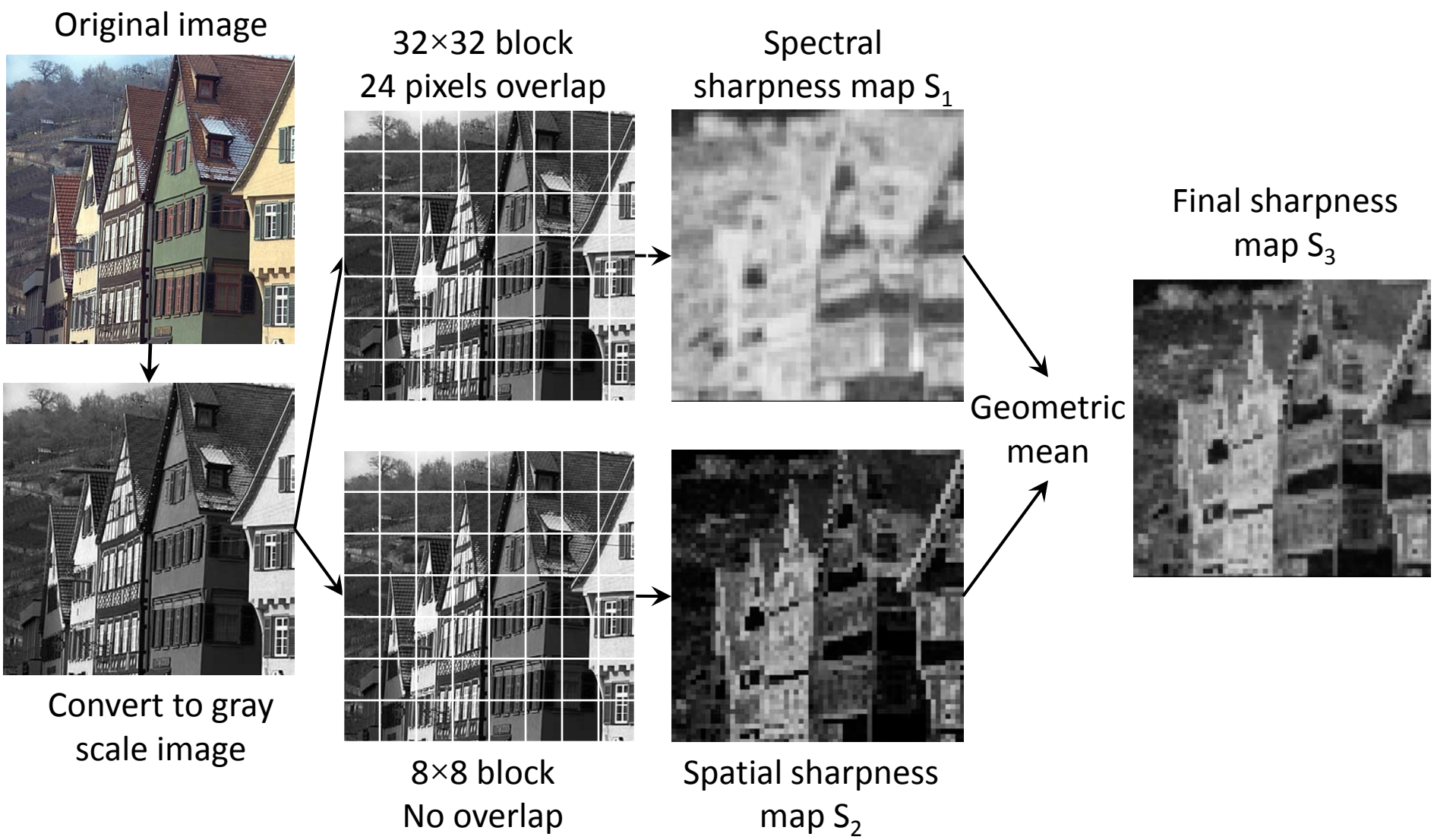
Outline

- Introduction
- **Algorithm**
  - Feature Measurement
- Results and Analysis
- Conclusion and Future work

Features

- Sharpness
- Color Distance
- Lightness Distance
- Contrast
- Edge Strength

Sharpness[1]

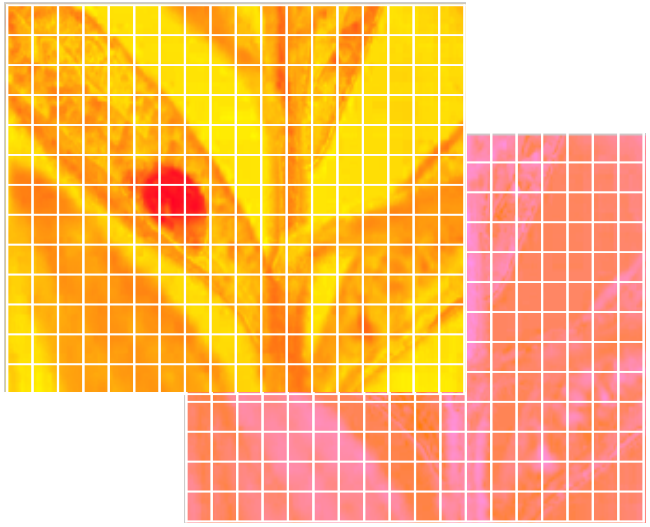


[1] C. T. Vu, and D. M. Chandler, "S3: A Spectral and Spatial Sharpness Measure", *IEEE Intl. Conference on Advances in Multimedia*, 2009

Color Distance

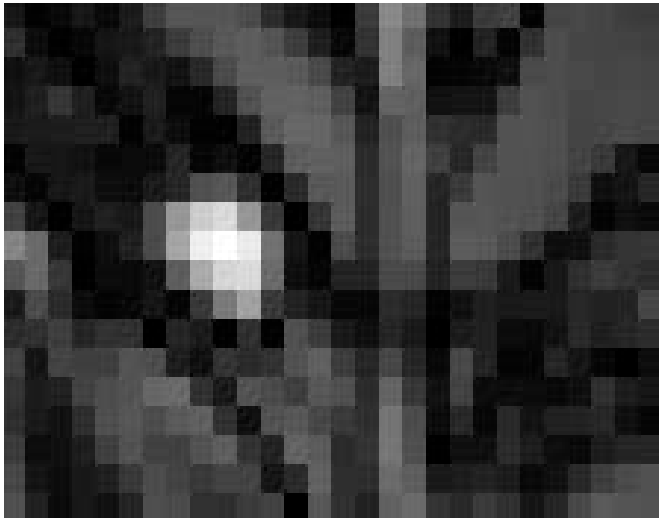
(1) Original image

(2) Convert to *a**, *b**



(3) 8x8 blocks w/ 50% overlap

Measure dist. from avg. block *a**, *b** to avg. bkgnd *a**, *b**

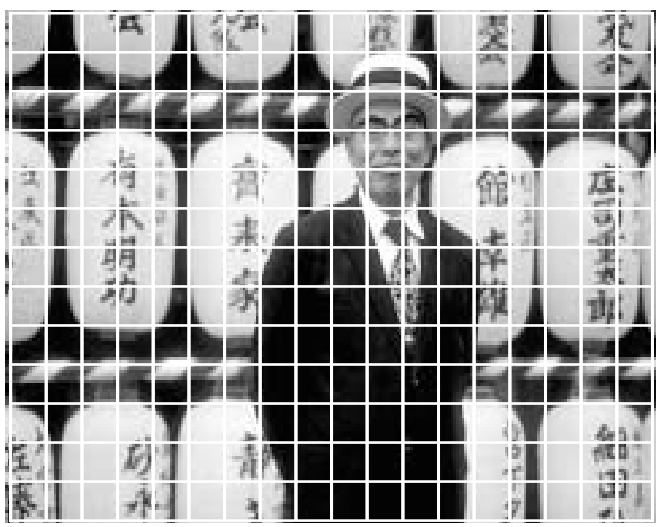


Local color dist. map

Lightness Distance

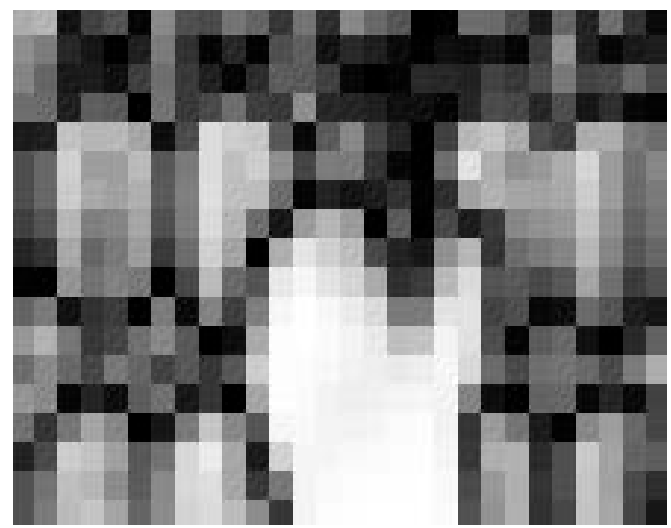
(1) Original image

(2) Convert to *L**



(3) 8x8 blocks w/ 50% overlap

Measure dist. from avg. block *L**, to avg. bkgnd *L**

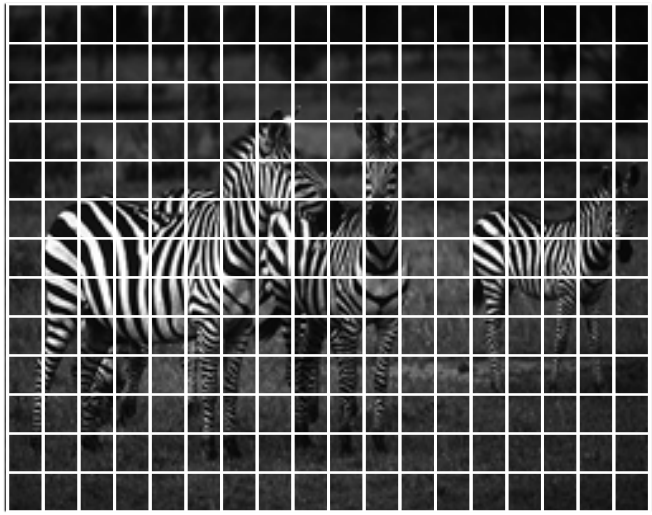


Local lightness dist. map

RMS Contrast

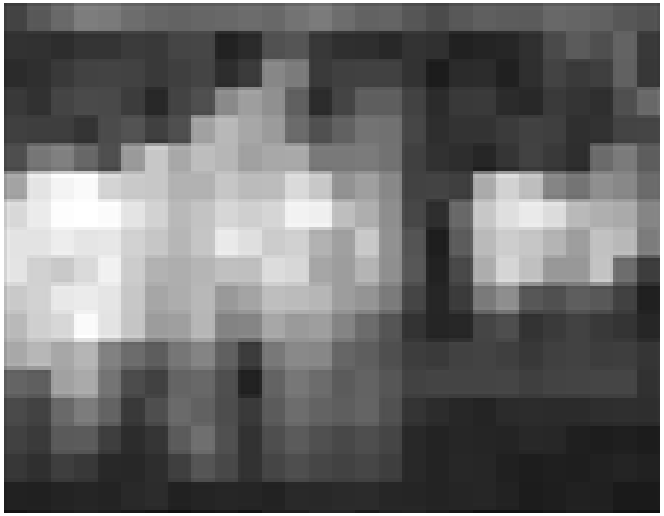
(1) Original image

(2) Convert to luminance



(3) 8x8 blocks w/ 50% overlap

Measure
avg. block
RMS contrast

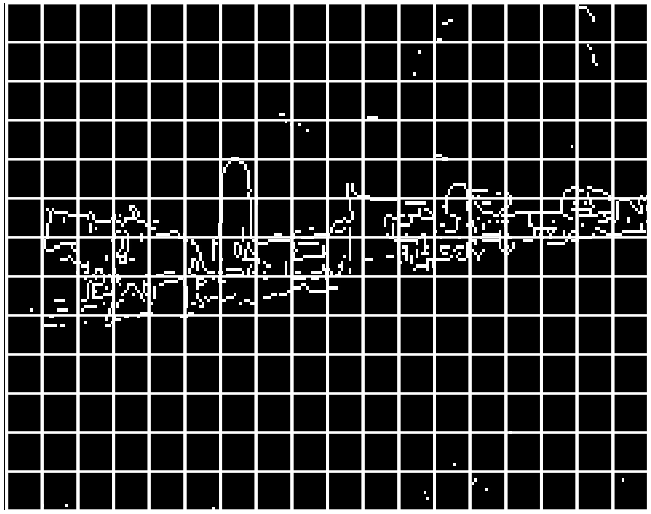


Local contrast map

Edge Strength

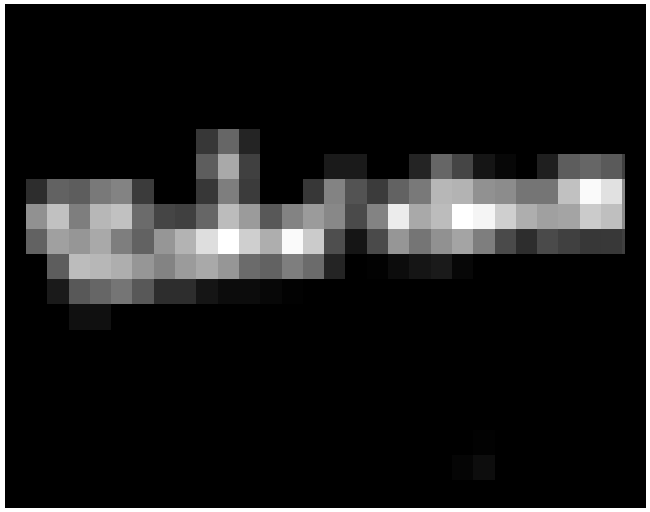
(1) Original image

(2) Run Robert's edge detector



(3) 8x8 blocks w/ 50% overlap

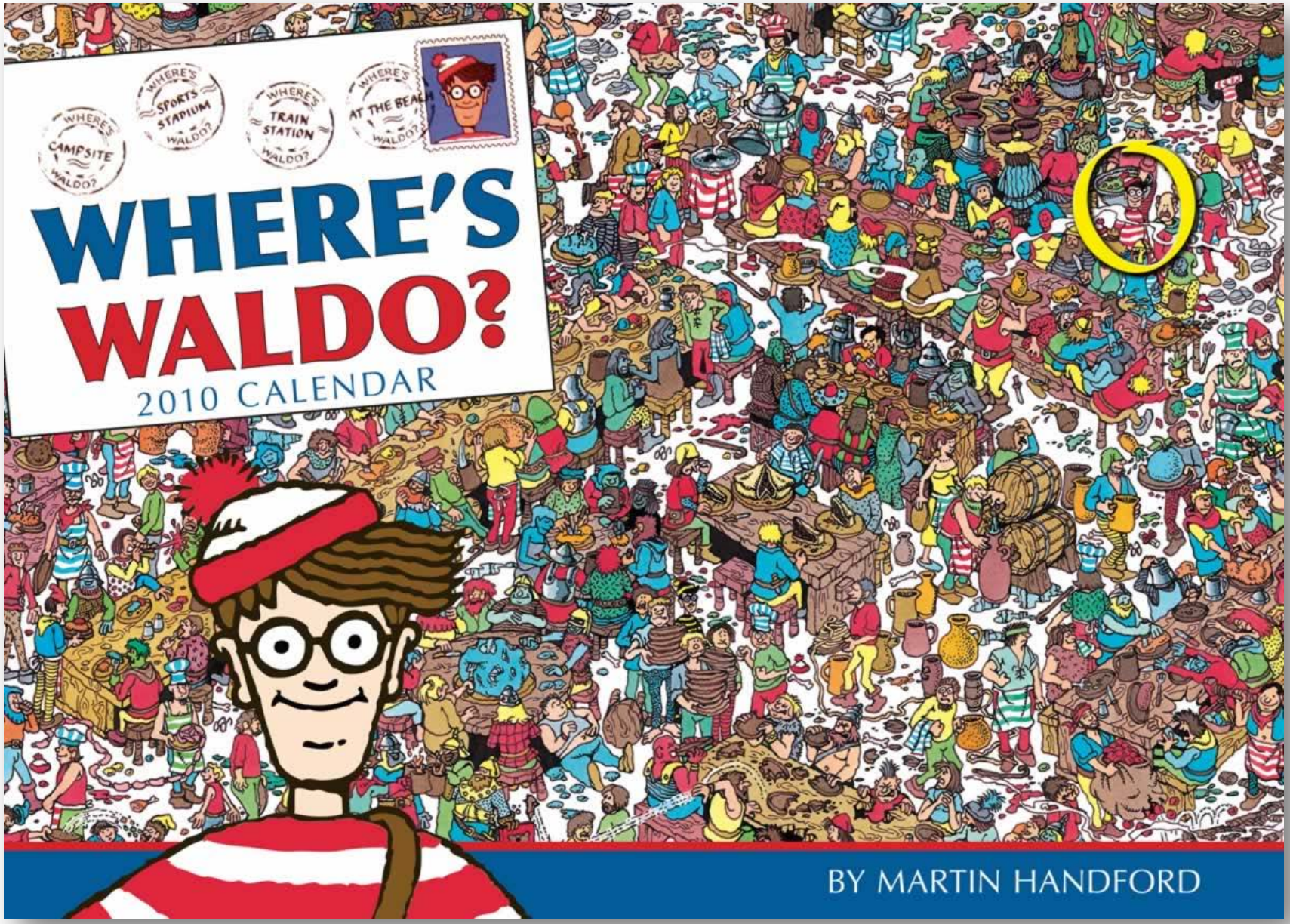
Measure avg. block edge pixels

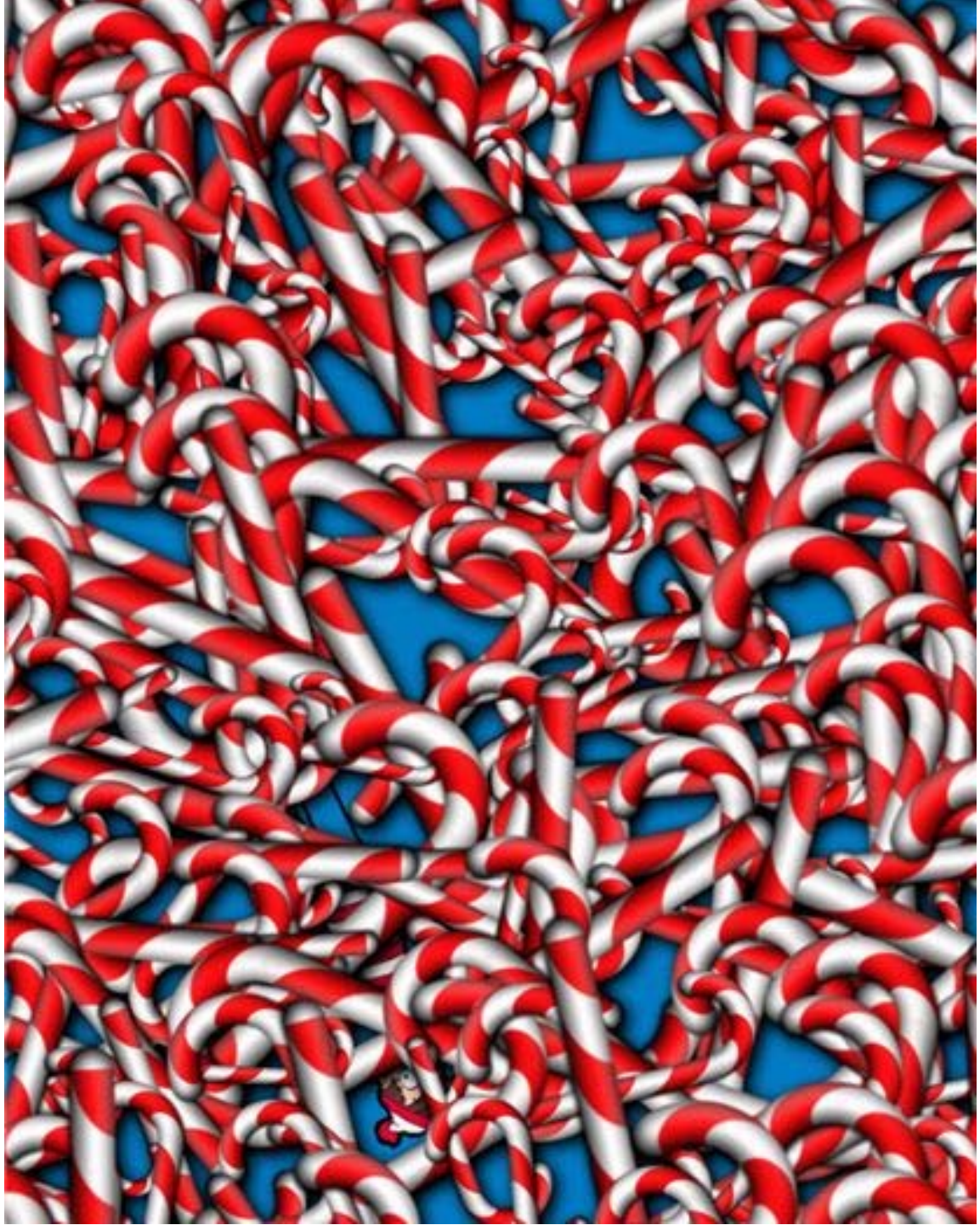


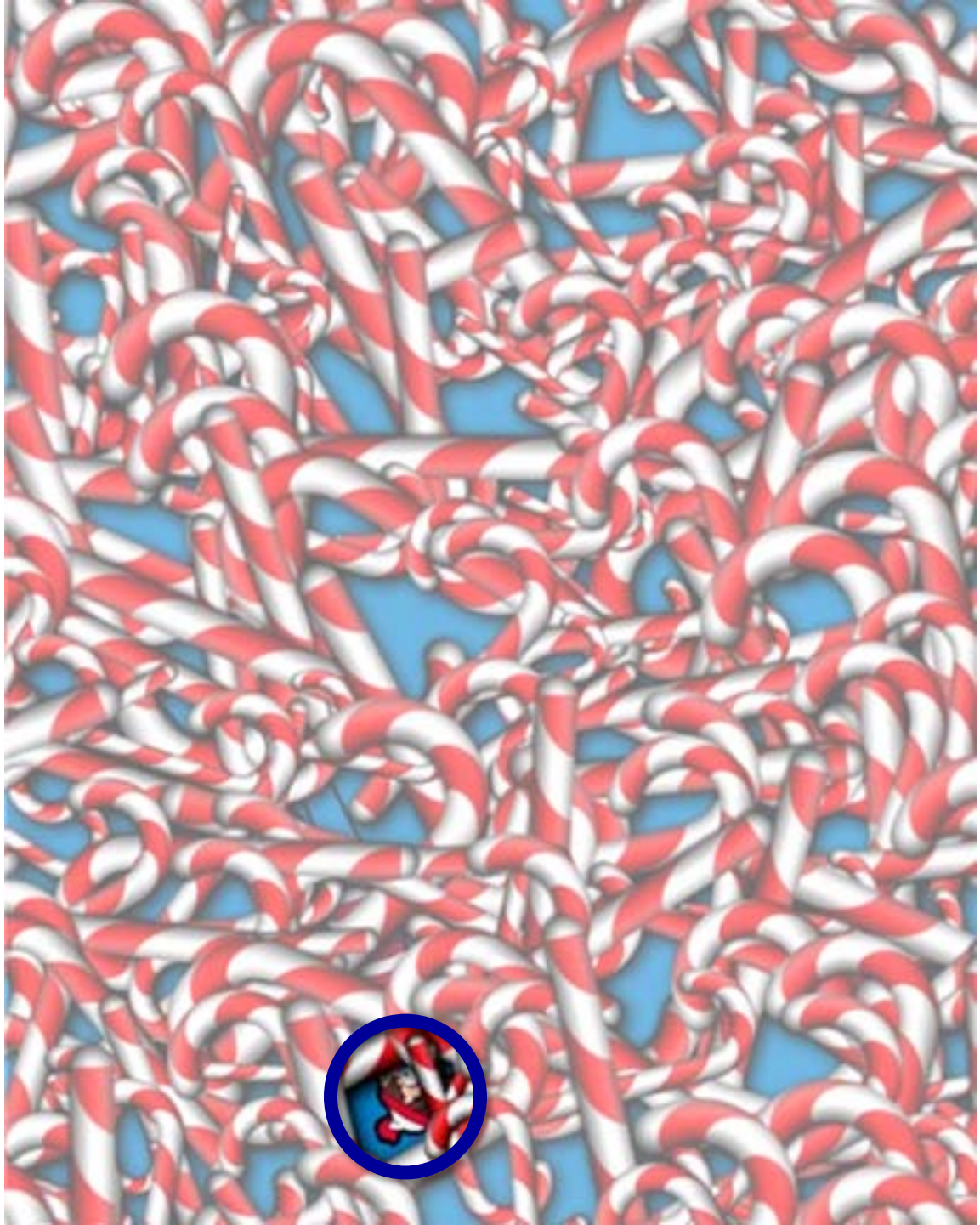
Local edge strength map

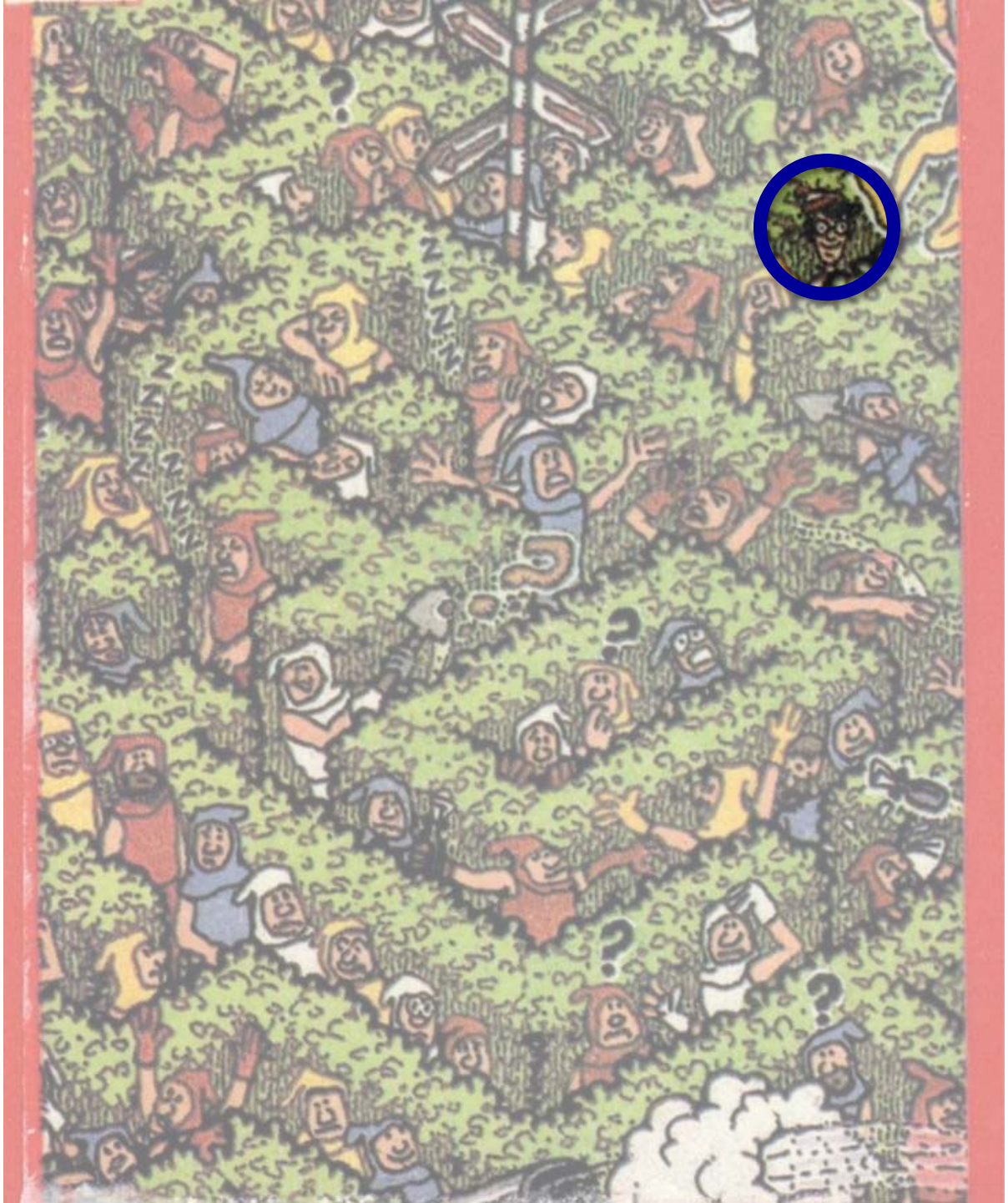
Outline

- Introduction
- **Algorithm**
  - o Feature Measurement
  - o Adaptive Feature Selection
- Results and Analysis
- Conclusion and Future work

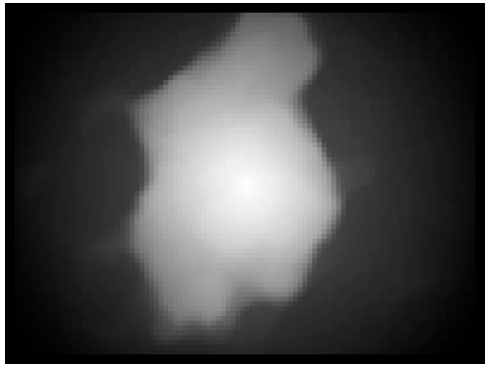

WHERE'S CAMPSITE WALDO?
WHERE'S SPORTS STADIUM WALDO?
WHERE'S TRAIN STATION WALDO?
WHERE'S AT THE BEACH WALDO?
WHERE'S WALDO?
2010 CALENDAR
BY MARTIN HANDFORD



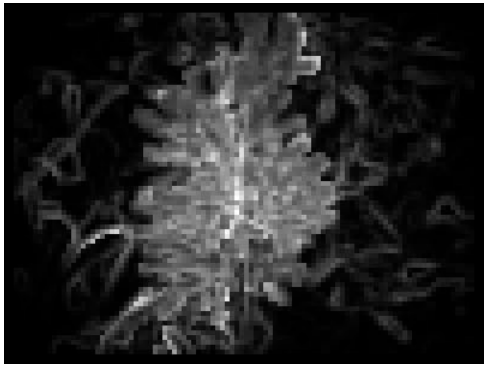




Adaptive feature selection

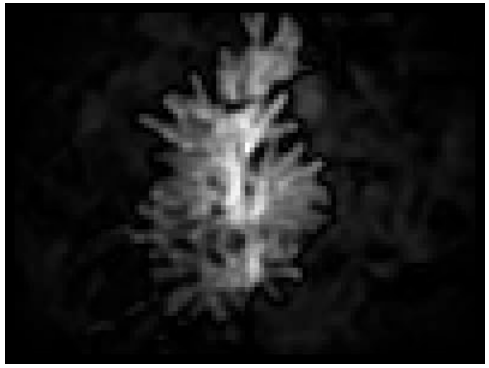


Sharpness

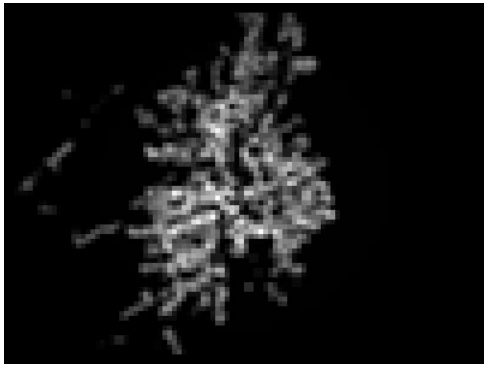


Contrast

Lightness



Color



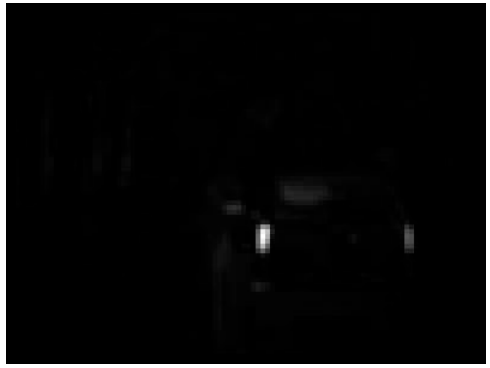
Edge

Adaptive feature selection

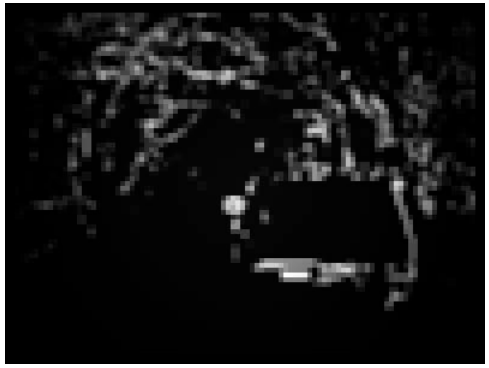
Sharpness

Contrast

Lightness



Color



Edge

Adaptive feature selection

How to measure the usefulness of a feature?

Sharpness

Contrast

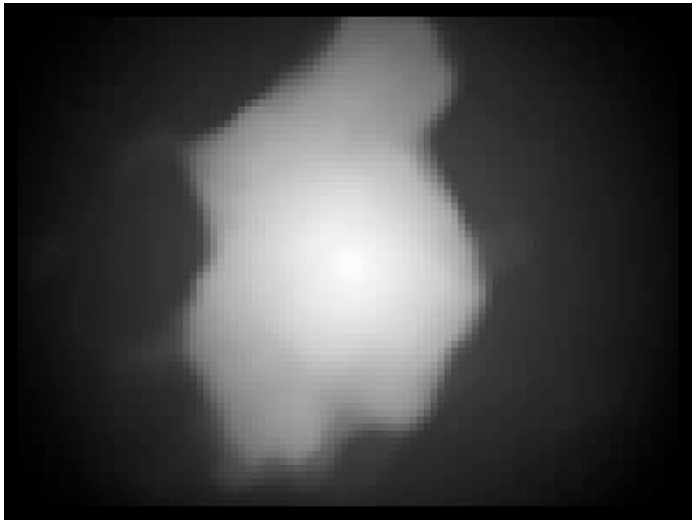
Lightness

Color

Edge

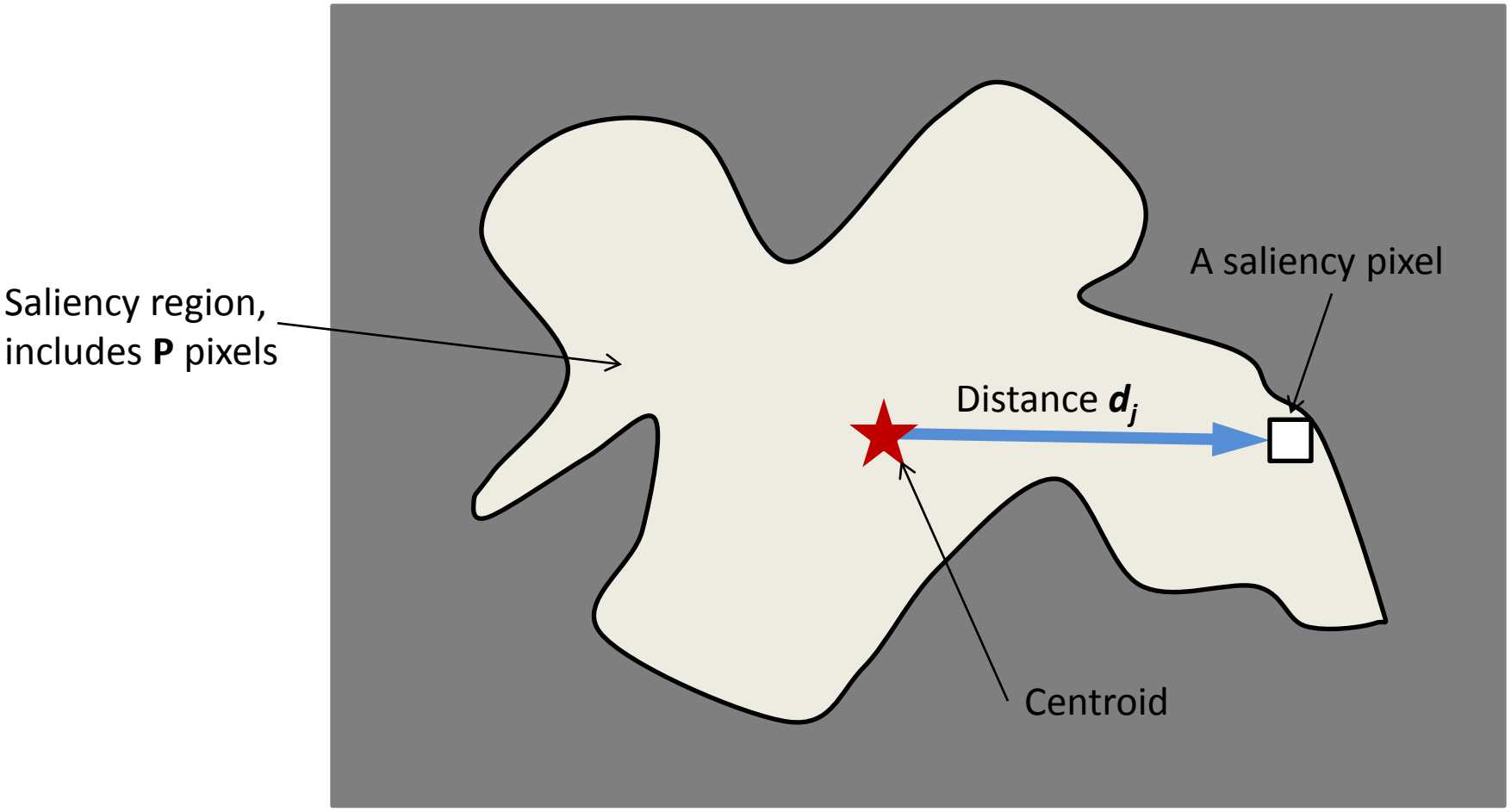
Cluster distance

Clustered



Non-clustered

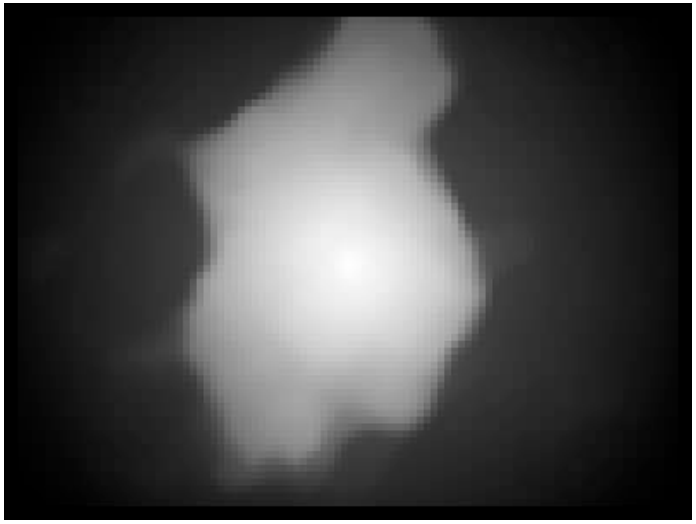
The more clustered, the better!!!



Cluster Distance $$\beta = \frac{\sum d_j}{P^{\alpha}}$$

Cluster distance

Low cluster distance



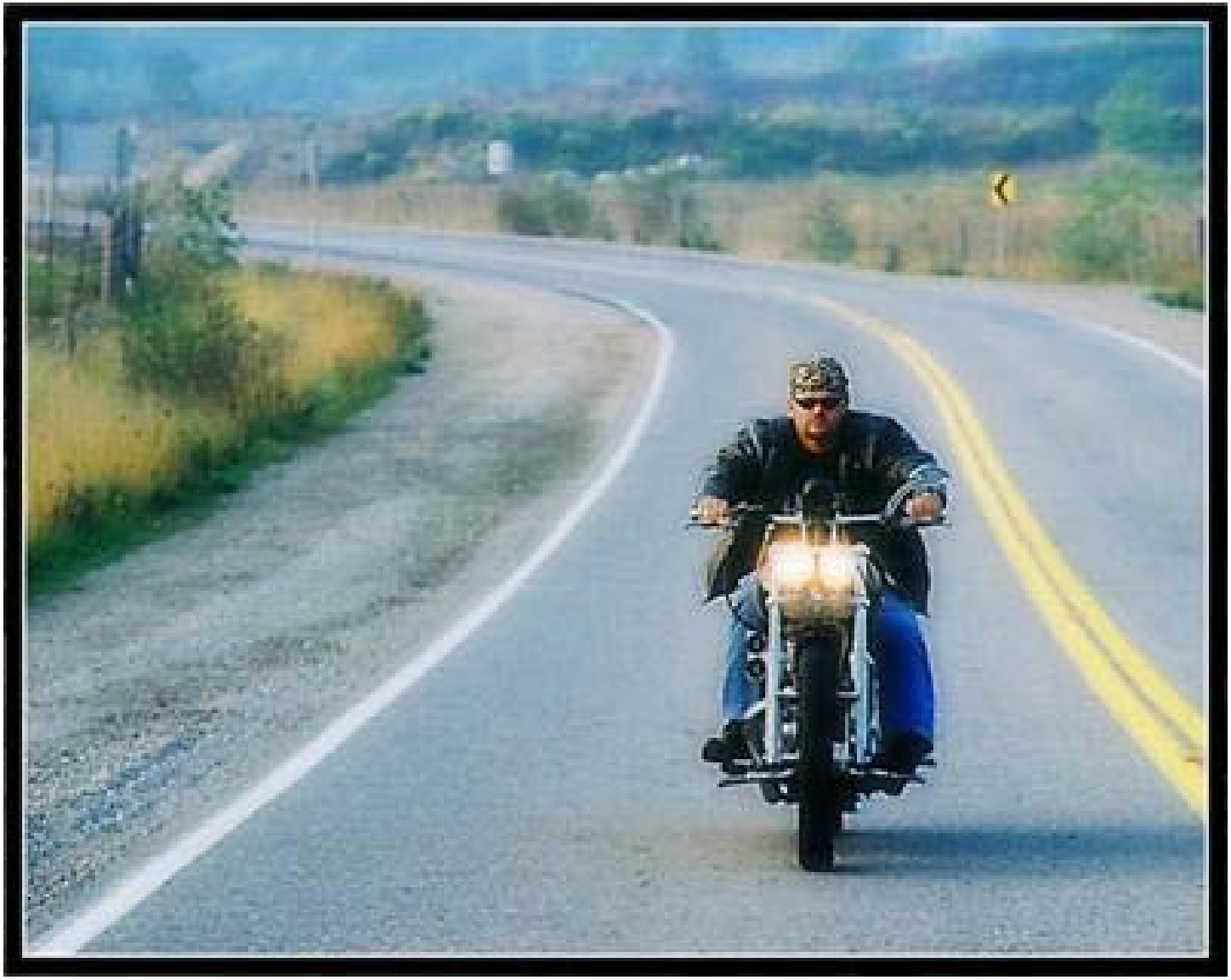
Cluster Distance = 11.07

High cluster distance

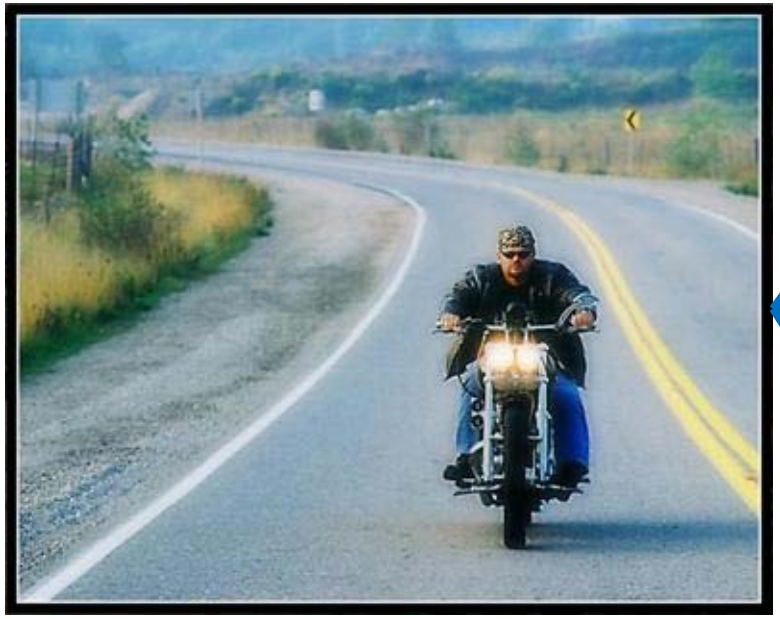
Cluster Distance = 18.56

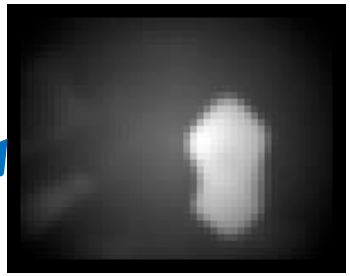
Outline

- Introduction
- **Algorithm**
  - o Feature
  - o Adaptive Feature Selection
  - o Multi-stage Refinement
- Results and Analysis
- Conclusion and Future work



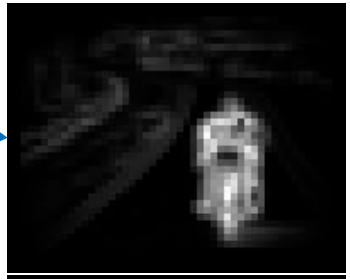
Stage 1: Measure Features





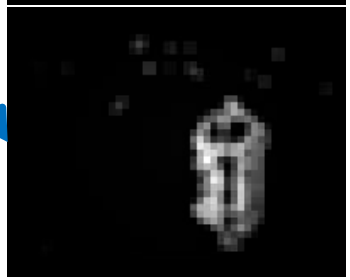
Sharpness

Lightness Distance



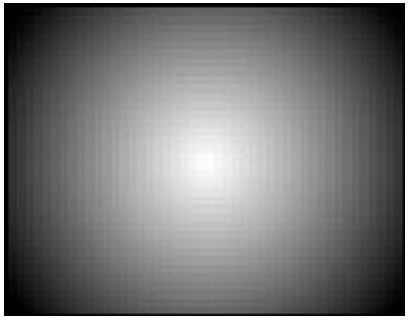
Contrast

Color Distance

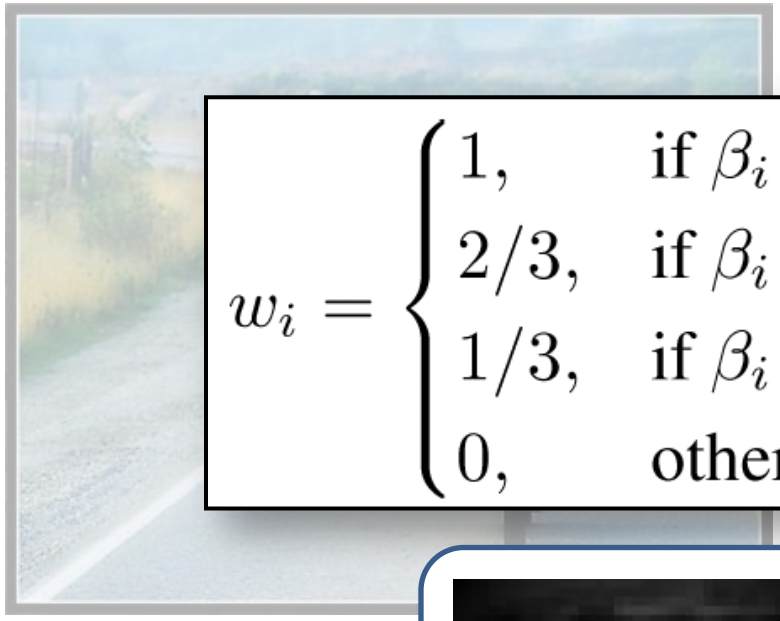


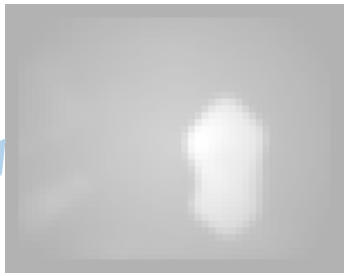
Edge Strength

Spatial weighting



Stage 1: Measure Features

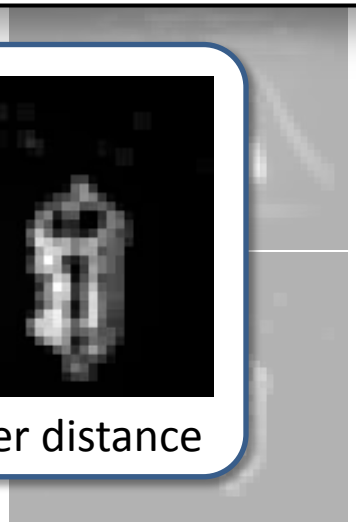




Sharpness

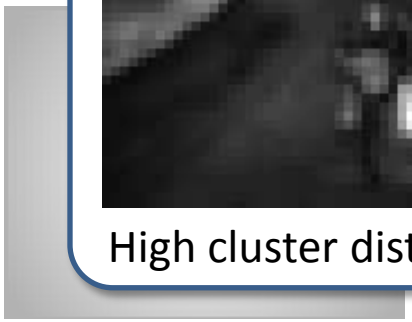
Lightness

$$w_i = \begin{cases} 1, & \text{if } \beta_i = \tilde{\beta}_5 \\ 2/3, & \text{if } \beta_i = \tilde{\beta}_4 \\ 1/3, & \text{if } \beta_i = \tilde{\beta}_3 \\ 0, & \text{otherwise} \end{cases}, \quad \text{where} \quad \tilde{\beta} = \text{sort}\{\beta_i\}$$

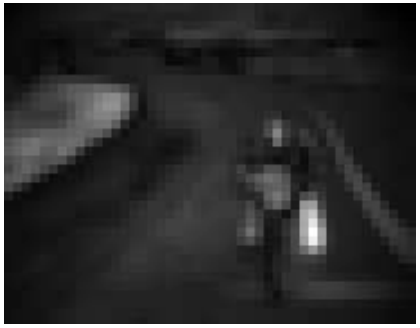


Color

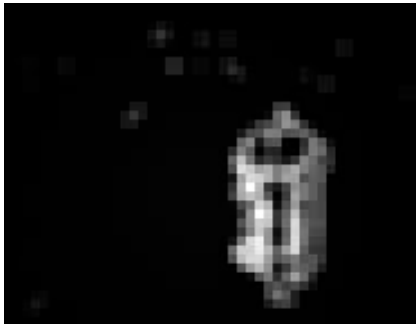
Edge Strength



Spatial weighting

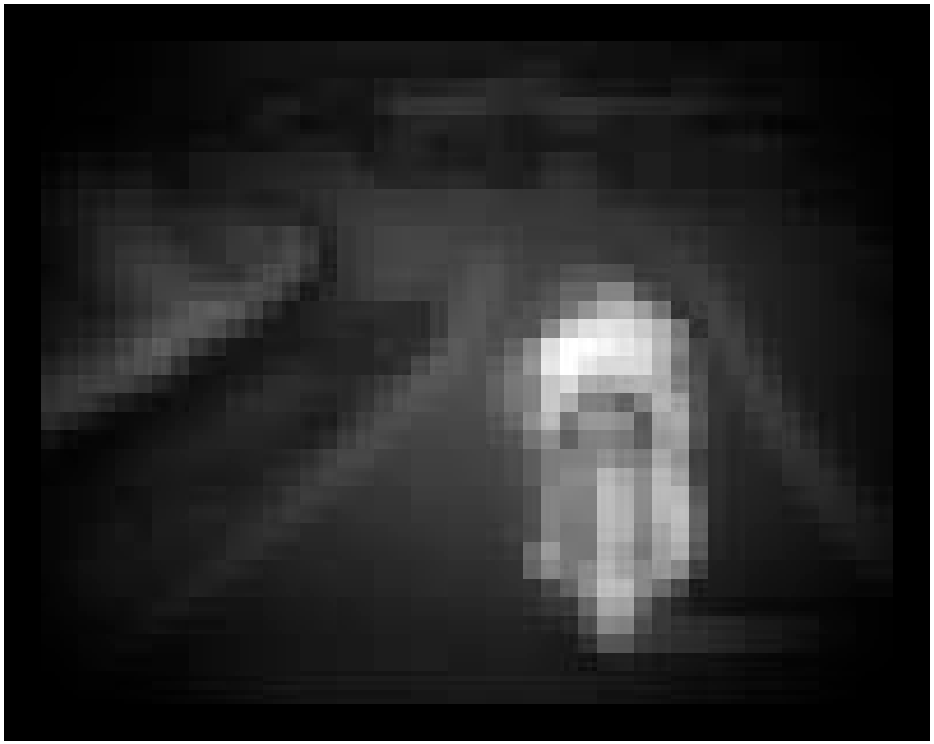


High cluster distance

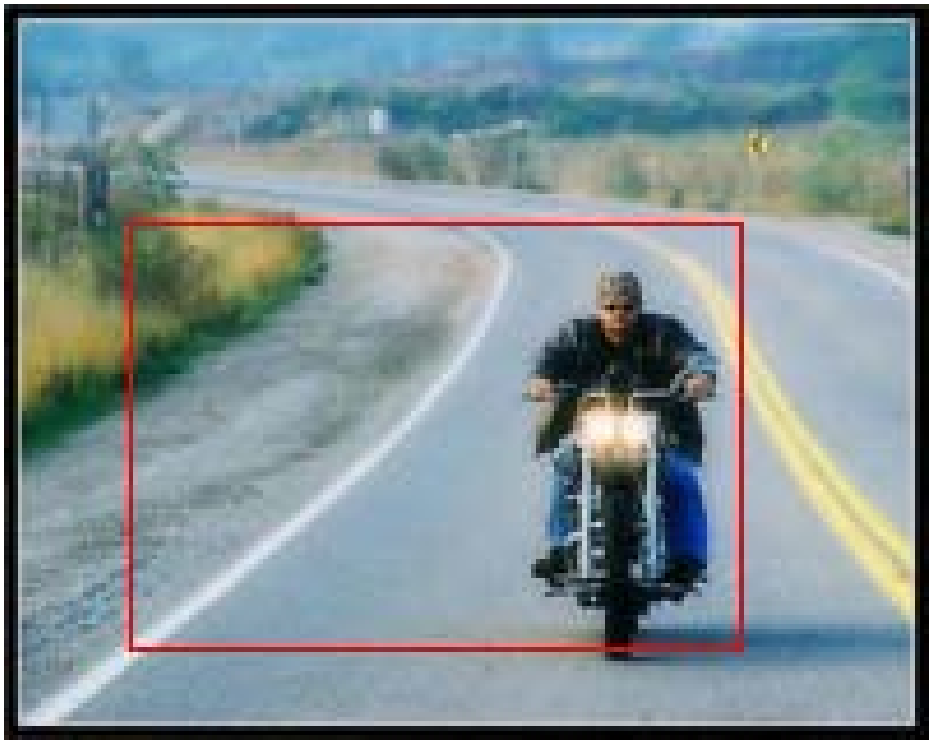


Low cluster distance

Stage 1 map

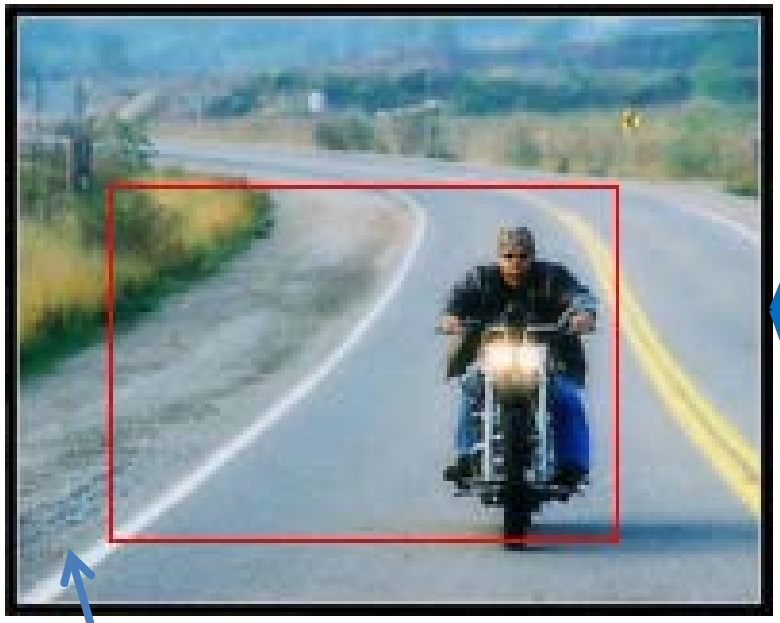


Stage 1 rectangle



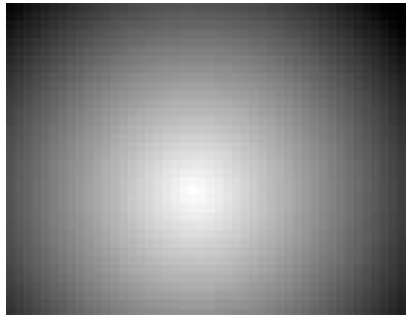
✓ Saliency pixels: Greater than T = 1.5 × mean(***map***)

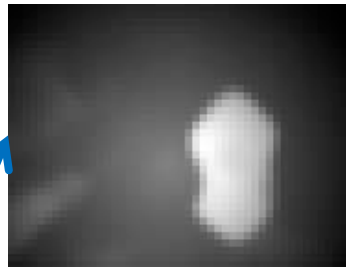
Stage 2: Refine Features



Background

Spatial weighting





Sharpness

Lightness Distance

To the new background

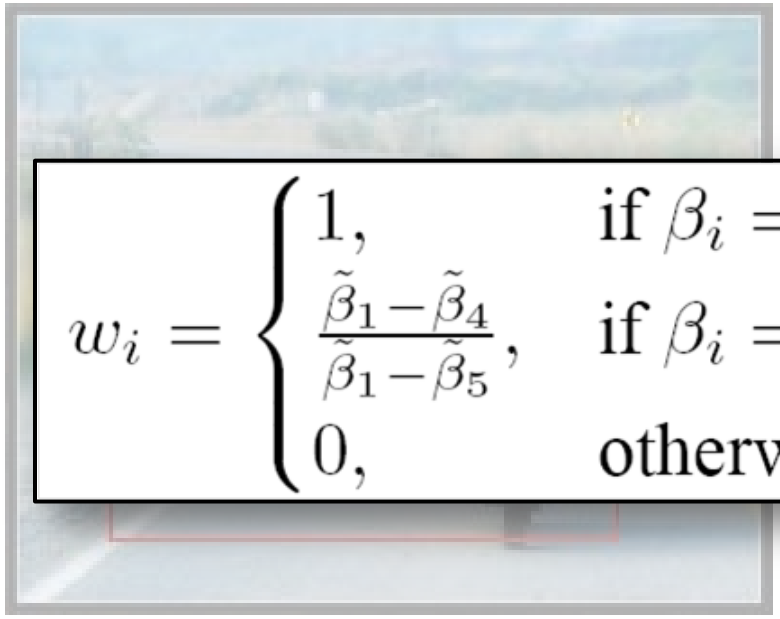
Contrast

Color Distance

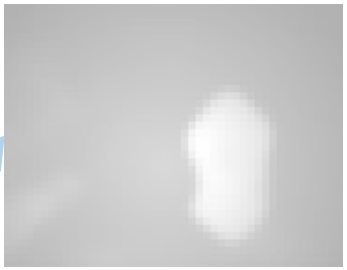
To the new background

Edge Strength

Stage 2: Refine Features



$$w_i = \begin{cases} 1, & \text{if } \beta_i = \tilde{\beta}_5 \\ \frac{\tilde{\beta}_1 - \tilde{\beta}_4}{\tilde{\beta}_1 - \tilde{\beta}_5}, & \text{if } \beta_i = \tilde{\beta}_4 \\ 0, & \text{otherwise} \end{cases}, \quad \text{where} \quad \tilde{\beta} = \text{sort}\{\beta_i\}$$



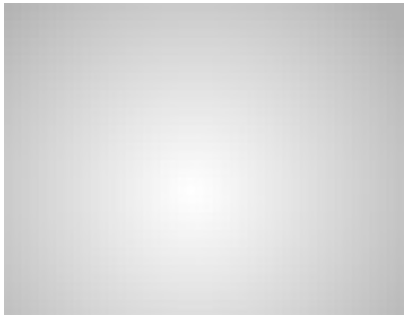
Sharpness

Lightness

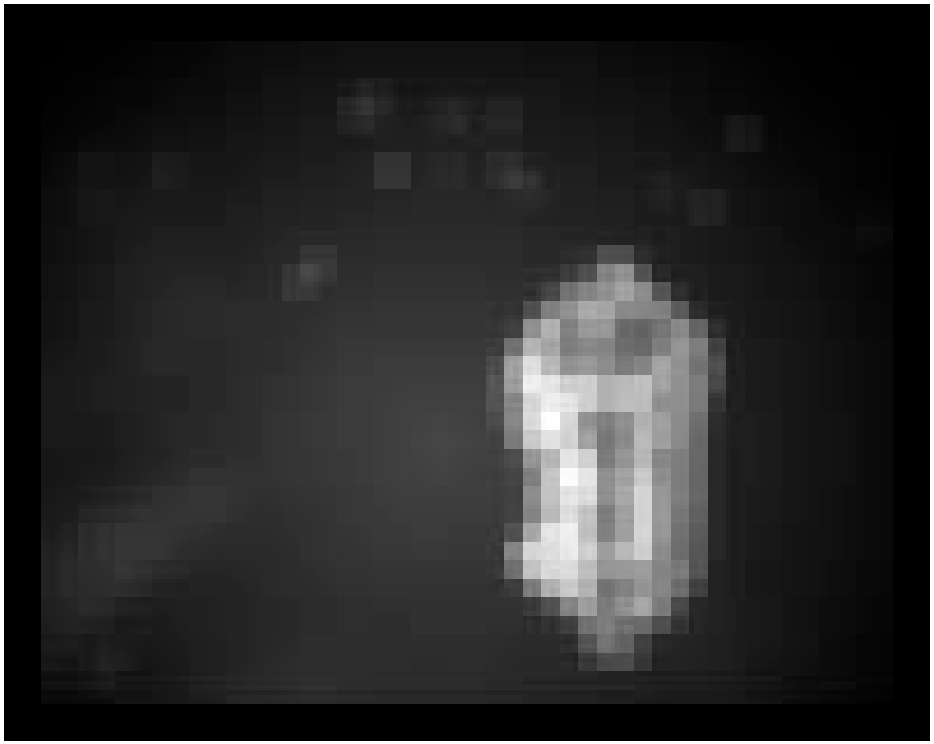
Color

Edge Strength

Spatial weighting



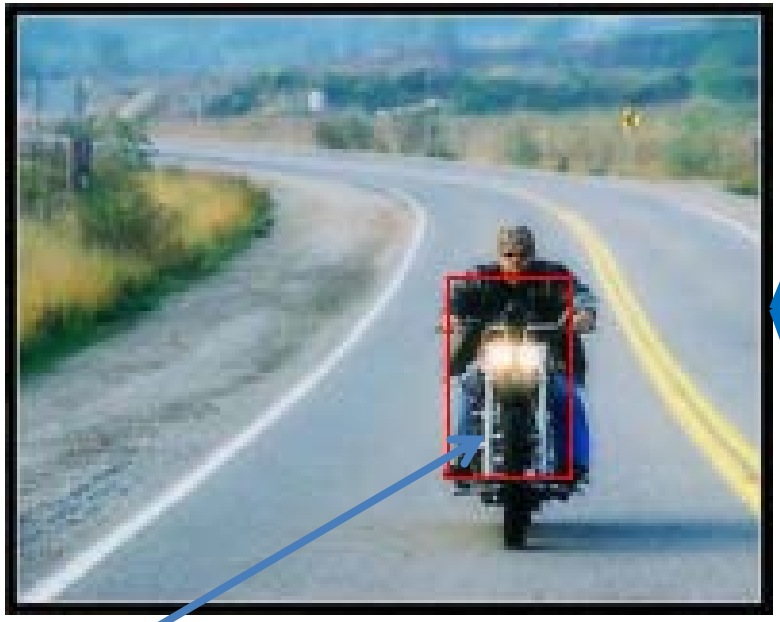
Stage 2 map



Stage 2 rectangle

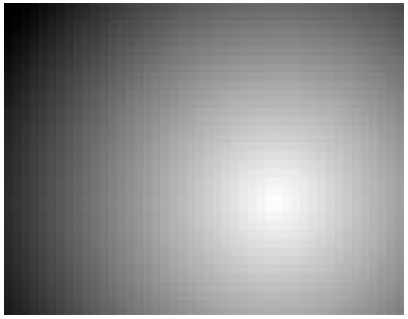
- ✓ Saliency pixels: Greater than T = 2 × mean(***map***)
- ✓ Take only 75% of saliency pixels

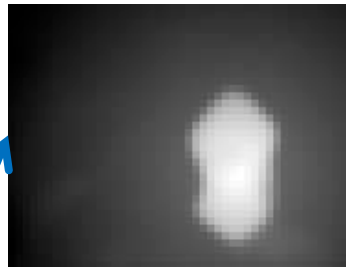
Stage 3: Refine Features Again



Foreground

Spatial weighting





Sharpness

Lightness Distance

To the new foreground

Contrast

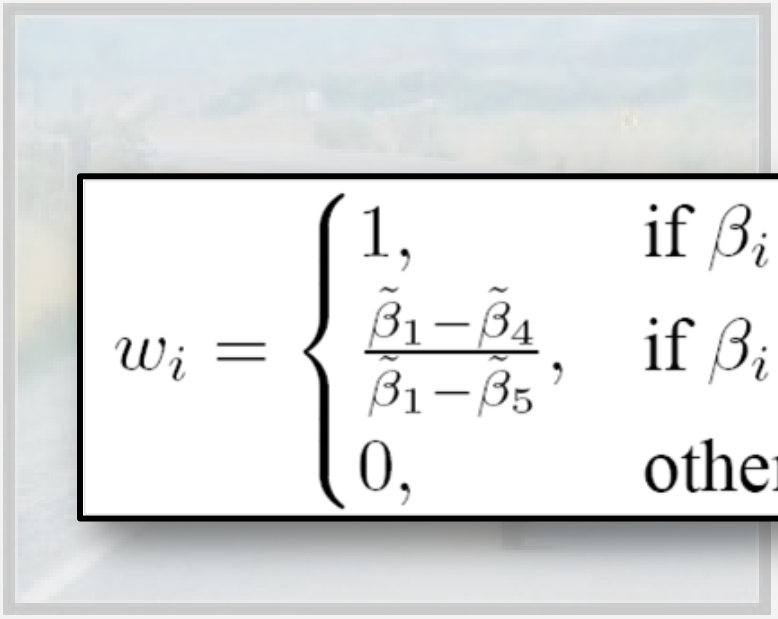
Color Distance

To the new foreground

Edge Strength

Stage 3: Refine Features Again

(Distance to the foreground)



$$w_i = \begin{cases} 1, & \text{if } \beta_i = \tilde{\beta}_5 \\ \frac{\tilde{\beta}_1 - \tilde{\beta}_4}{\tilde{\beta}_1 - \tilde{\beta}_5}, & \text{if } \beta_i = \tilde{\beta}_4 \\ 0, & \text{otherwise} \end{cases}, \quad \text{where} \quad \tilde{\beta} = \text{sort}\{\beta_i\}$$

Sharpness

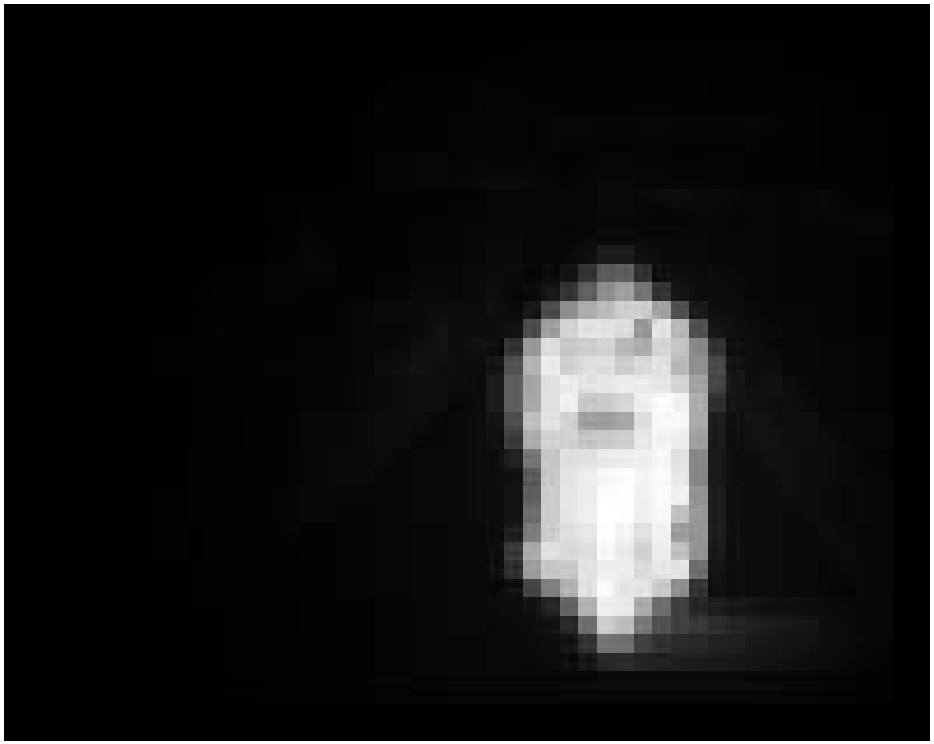
Lightness

Color

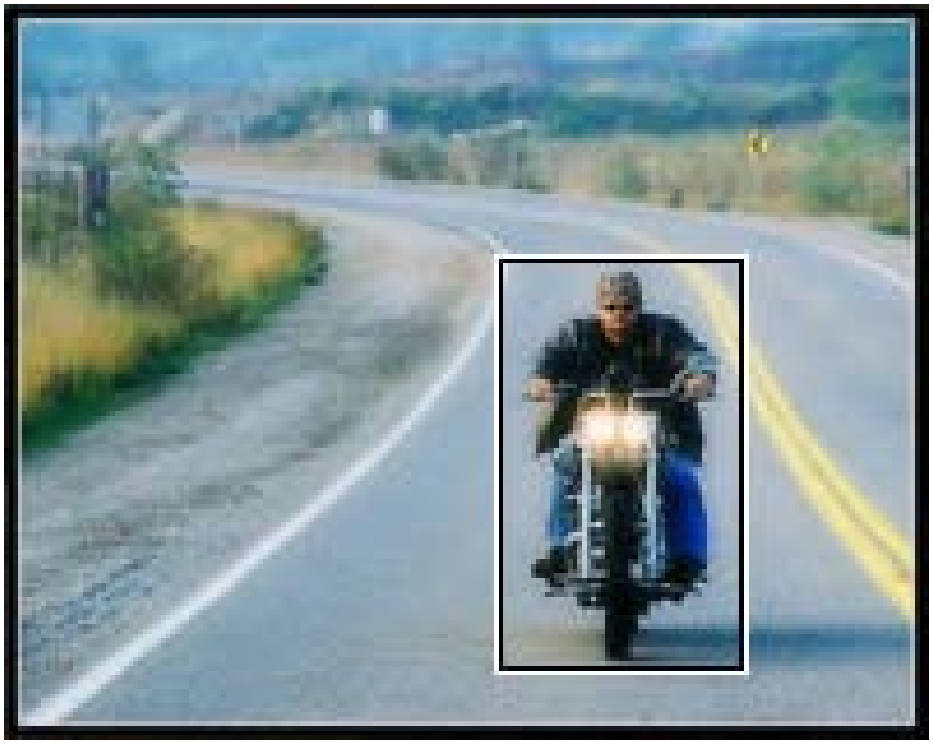
Edge Strength

Spatial weighting

Final map



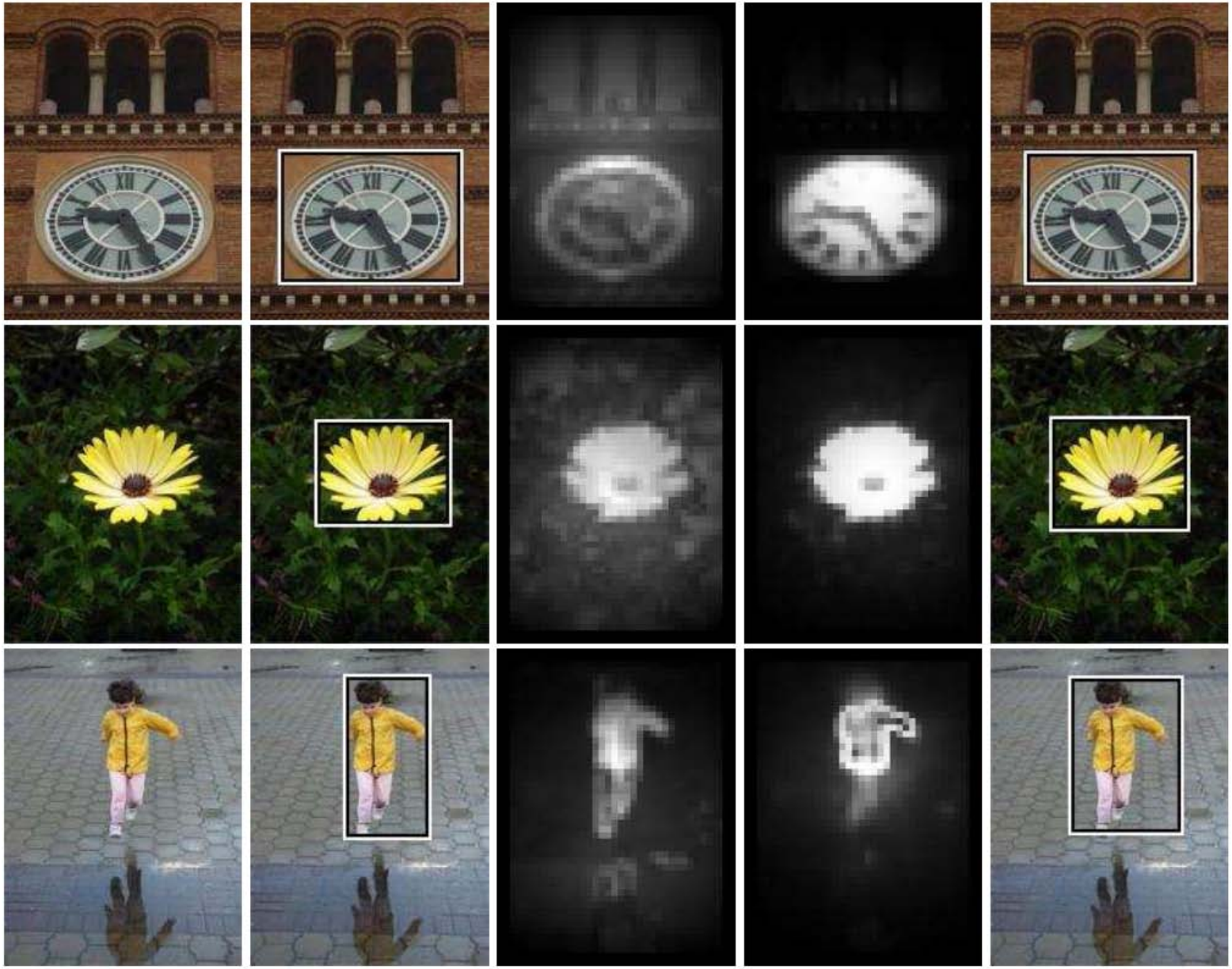
Final rectangle



✓ Saliency pixels: Greater than T = 1.5 × mean(***map***)

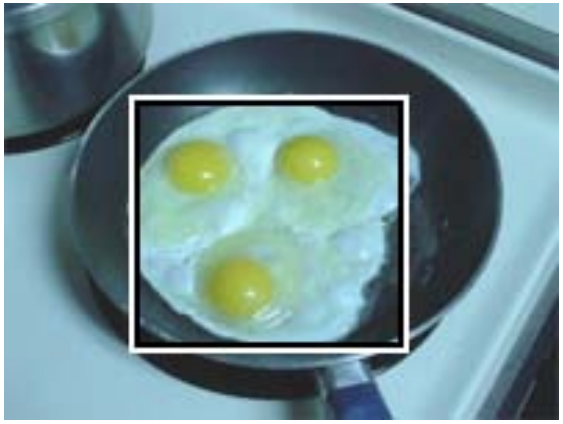
Outline

- Introduction
- Algorithm
- Results and Analysis
- Conclusion and Future work



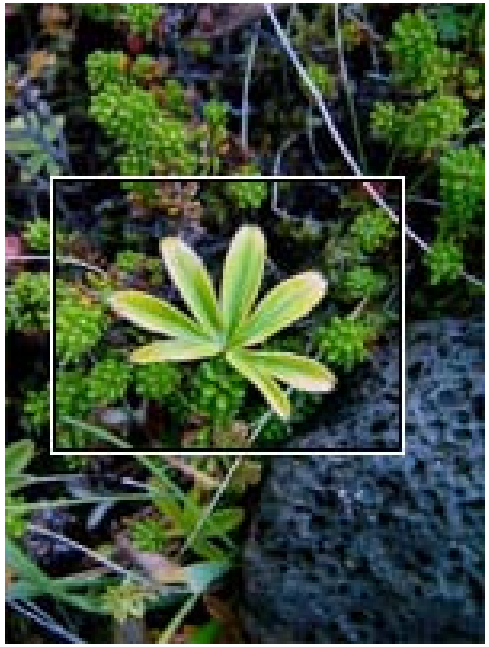
Original image | Ground truth | First stage map | Final map | MSD Result

MSD Results on Objects



MSD Results on Plants








MSD Results on People









MSD Results on Animals









MSD Failure Cases

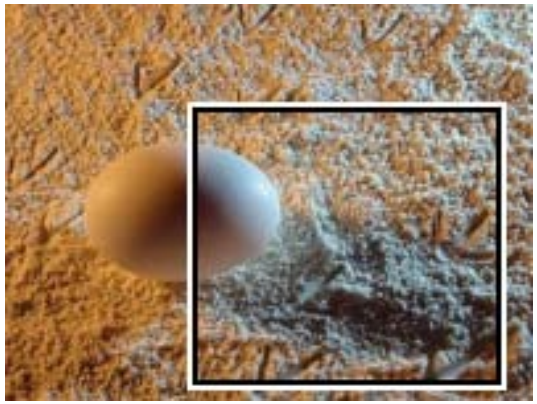









Image testing sets

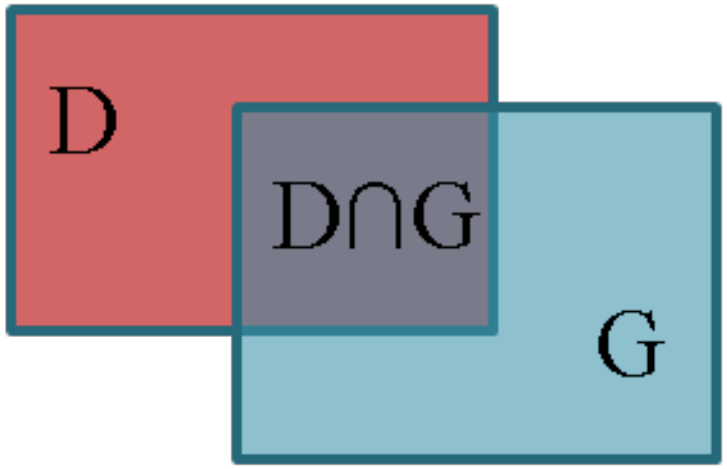
- MSRA database[2] : 5000 images (set B) with bounding box groundtruth

- EPFL database[3] : 1000 images from MSRA database with object-contour based groundtruth[3]

[2] T. Liu et al., "Learning to detect a salient object," IEEE Conference on Computer Vision and Pattern Recognition, 2007.
[3] R. Achanta et al., "Frequency-turned Salient Region Detection", IEEE Conference on Computer Vision and Pattern Recognition, 2009

Evaluation Criteria

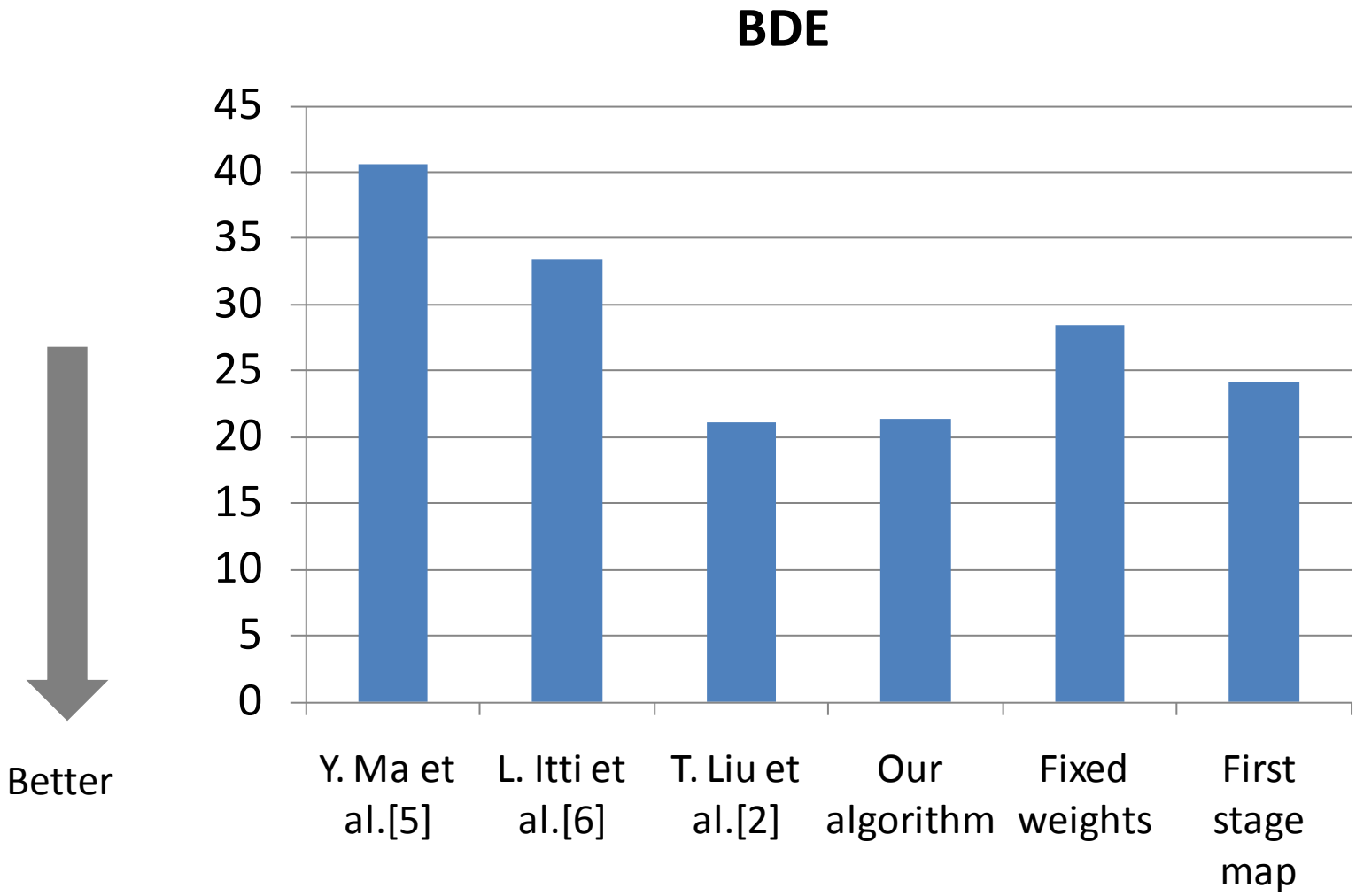
- Boundary-based Criterion:
  - BDE: Boundary Displacement Error[4] between the boundaries of Detected and Groundtruth rectangles
- Region-based Criteria



  - Precision = $\frac{A(D \cap G)}{A(D)}$
  - Recall = $\frac{A(D \cap G)}{A(G)}$
  - F-measure = $\frac{(1+\alpha) \times P \times R}{\alpha \times P + R}$

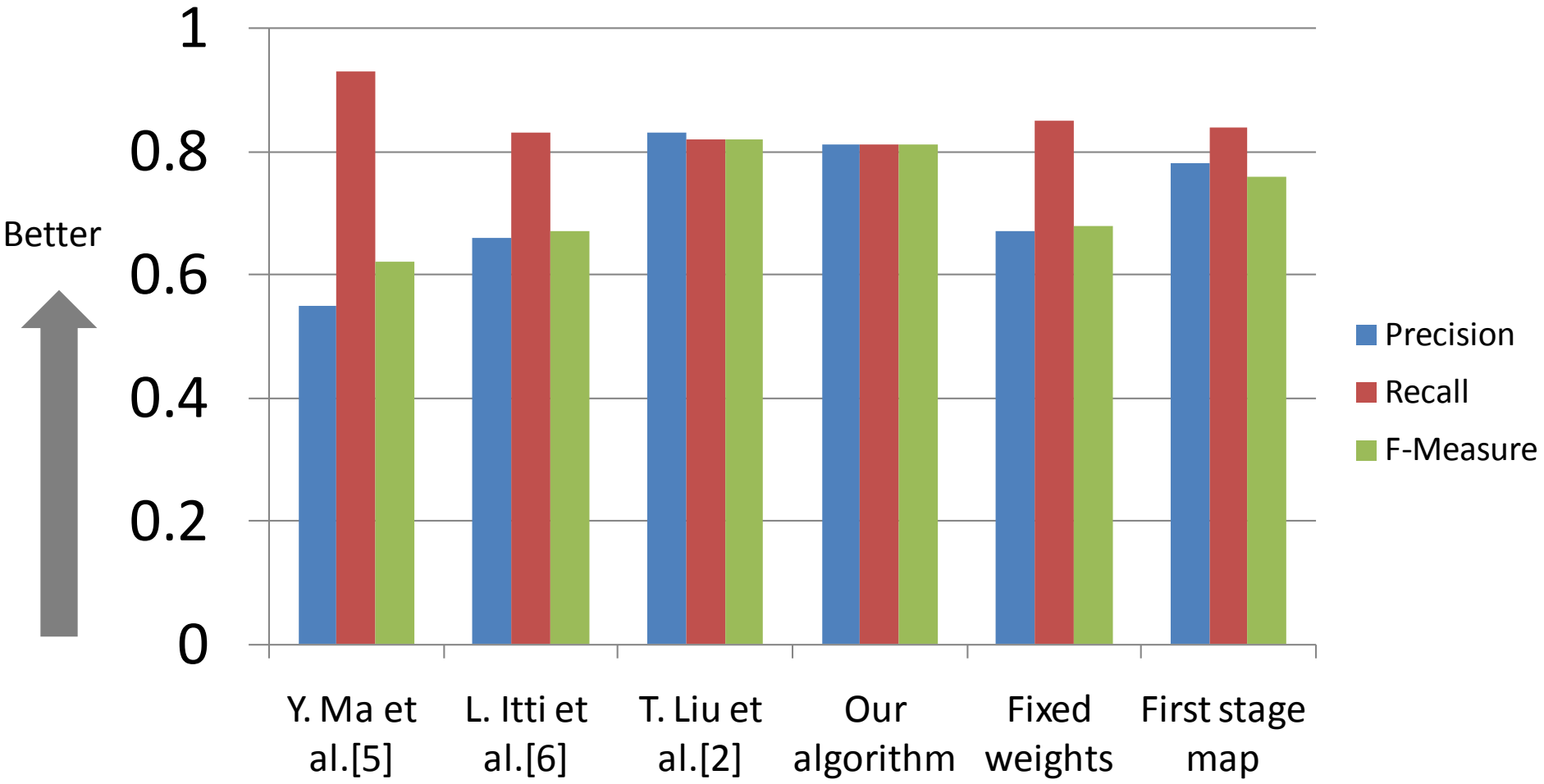
[4] J. Freixenet et al., "Yet another survey on image segmentation: Region and boundary information intergration," In ECCV, pages 408-422, 2002.

Overall Results – MSRA database

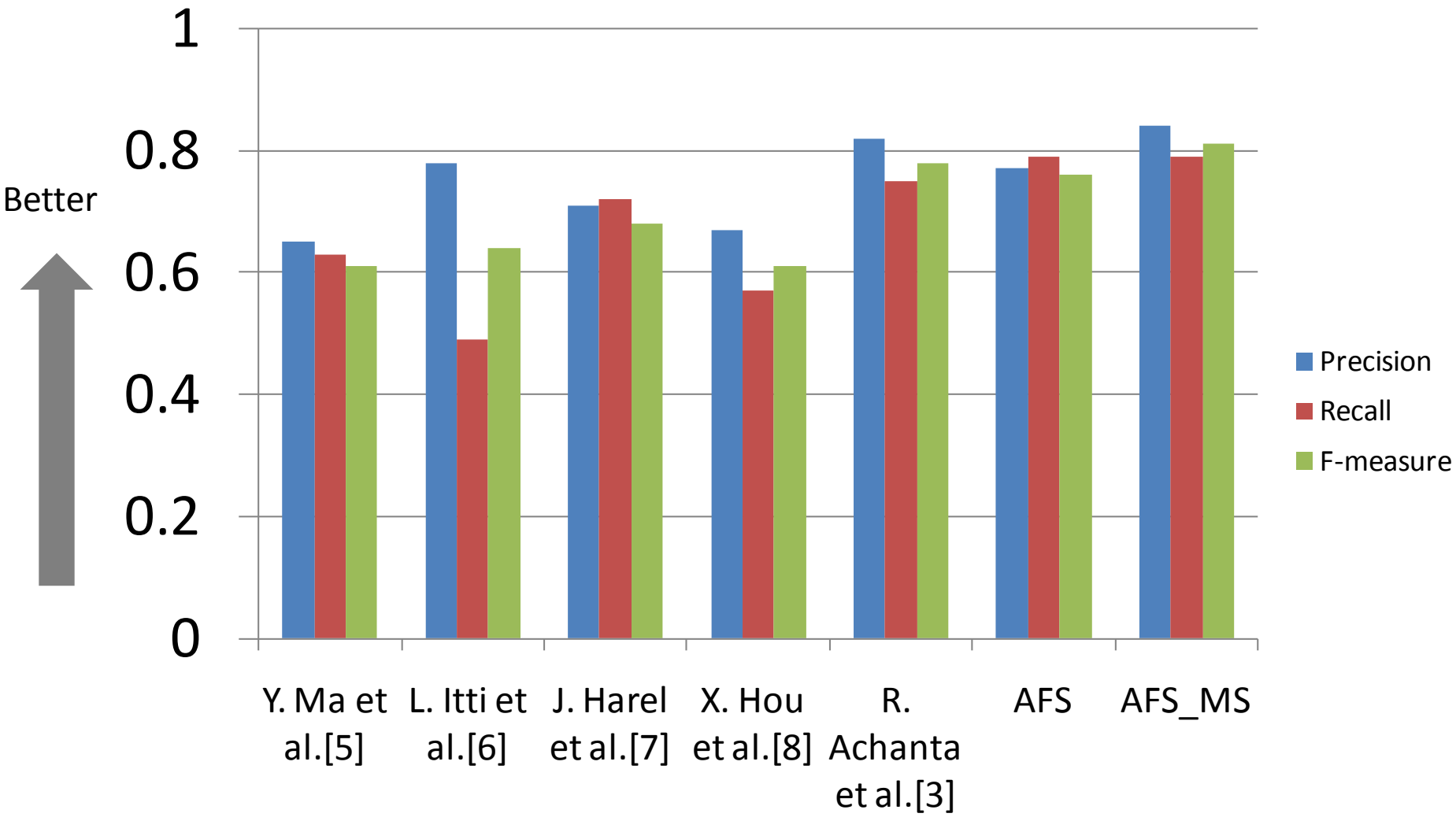


[5] Y. Ma et al., "Contrast-based image attention analysis by using fuzzy growing," in MULTIMEDIA '03, New York, USA, pp. 374-381, ACM, 2003.
[6] L. Itti et al., "A model of saliency-based visual attention for rapid scene analysis," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 20, no. 11, pp. 1254 – 1259, 1998.

Overall Results – MSRA database



Overall Results – EPFL database



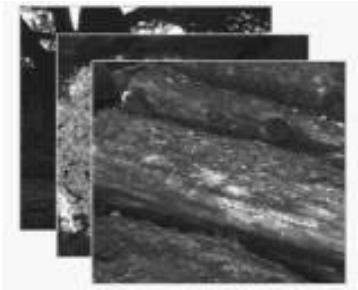
[7] J. Harel et al., "Graph-based visual saliency," Advances in Neural Information Processing Systems, 19:545-552, 2007.
[8] X. Hou et al., "Saliency detection: A spectral residual approach," IEEE Conference on Computer Vision and Pattern Recognition, 2007

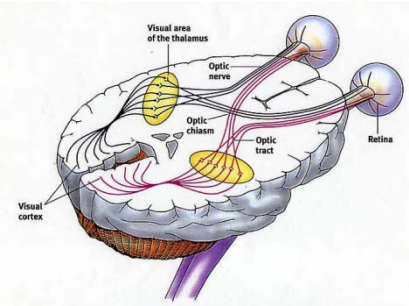
Average weighs of features

	Sharpness	Lightness Distance	Contrast	Color Distance	Edge Strength
Stage 1	**0.23**	0.22	0.10	**0.24**	0.21
Stage 2	**0.32**	0.23	0.06	**0.32**	0.07
Stage 3	**0.32**	0.21	0.08	**0.32**	0.07
Overall	**0.29**	0.22	0.08	**0.29**	0.12

Conclusion and Future work

- Relatively simple low-level features can be effective for MSD if they are combined in an adaptive and multi-stage fashion.
- Our results are very promising.
- This adaptive feature selection can be a useful strategy for other applications.
- Future works:
  - Improve the algorithm: new feature, using segmentation, etc
  - Multiple MSD

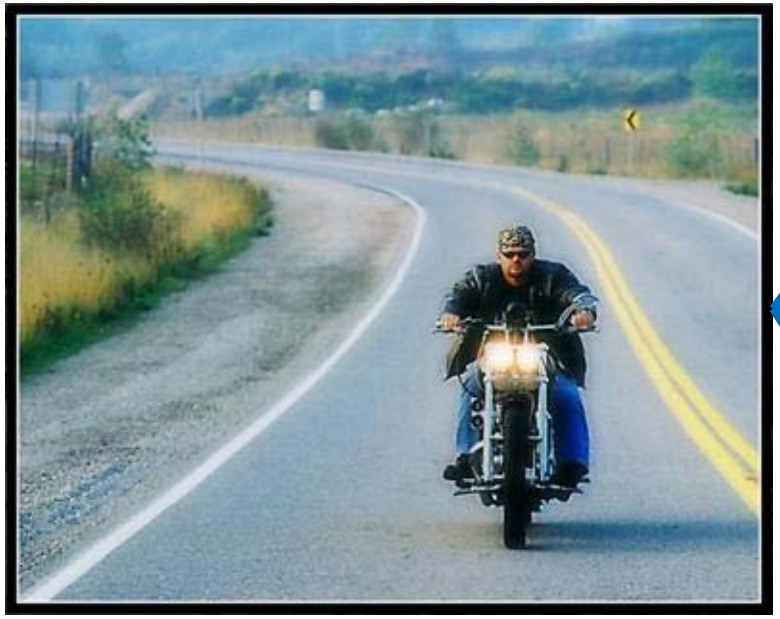


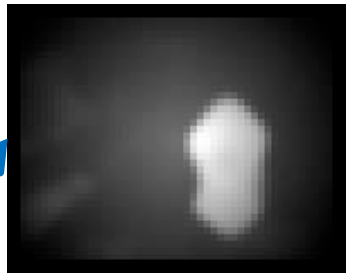


Thank you!

http://vision.okstate.edu
{cuong.vu, damon.chandler}@okstate.edu

Stage 1: Measure Features



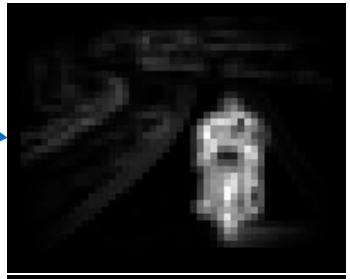


Sharpness

ω = 1

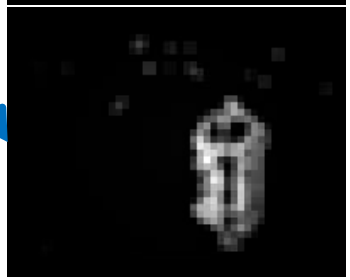
Lightness Distance

ω = 1/3



Contrast

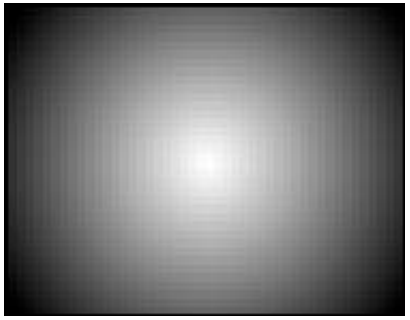
Color Distance



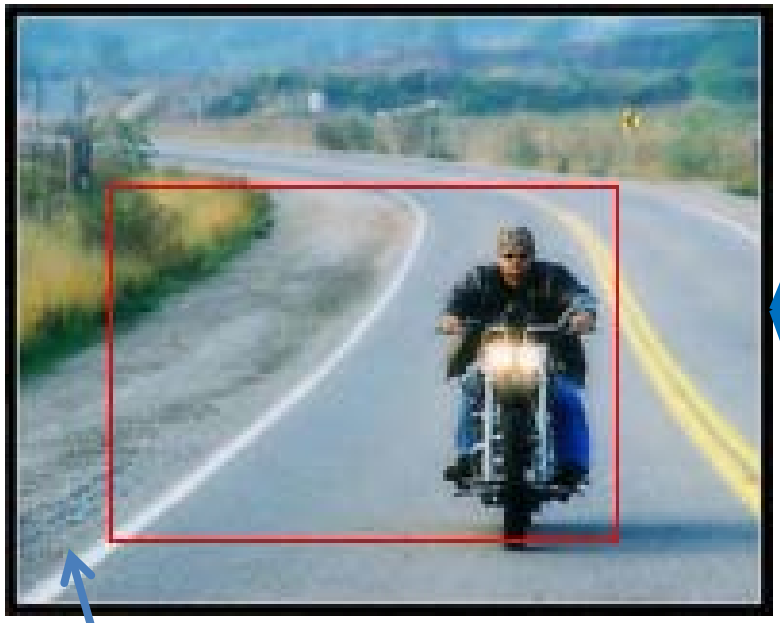
Edge Strength

ω = 2/3

Spatial weighting

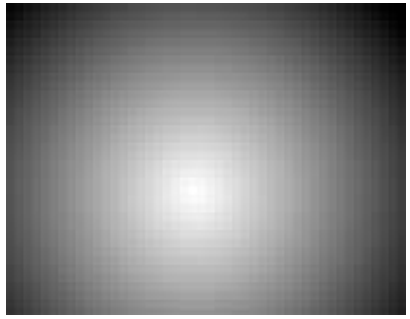


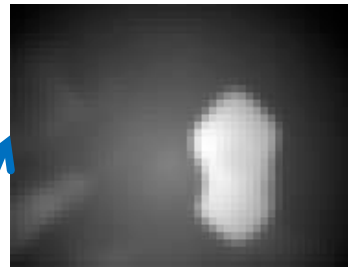
Stage 2: Refine Features



Background

Spatial weighting





Sharpness

ω = 0.826

Lightness Distance

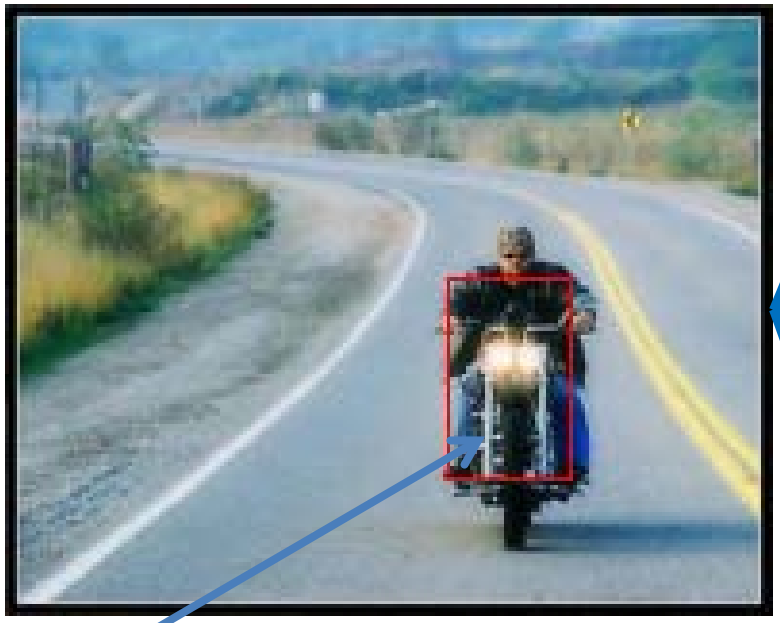
Contrast

Color Distance

Edge Strength

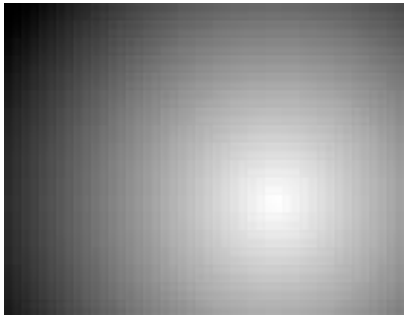
ω = 1

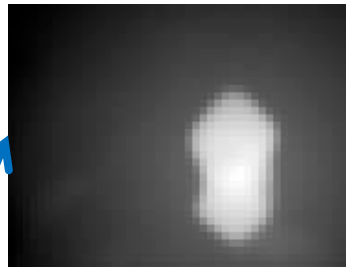
Stage 3: Refine Features Again



Foreground

Spatial weighting





Sharpness

ω = 0.95

Lightness Distance

Contrast

ω = 1

Color Distance

Edge Strength